Practical Shutdown and Turnaround Management for Engineers and Managers

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IDC TECHNOLOGIES

Technology Training that Works

Presents

Practical Shutdown and Turnaround Management for Engineers and Managers

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Management of shutdown and turnaround

Industrial plants have to undergo a scheduled process outage for the major maintenance work that is referred to as "plant shutdown" and the management of such 'plant shutdown' is known as the "plant turnaround". Turnaround (TA) has certain unique features in comparison to project management. There are several complexities involved with turnaround management in terms of technology, business and maintenance. Turnaround result mainly depends on the participative efforts of the team and demand focused performance objectives. It is an expensive process funded from the profits and involves risk and hazard. In this chapter we will discuss different phases of turnaround.

Learning objectives

- Project and turnaround management
- Component of turnaround work and principle of methodology
- Complexity of technology, business and maintenance
- Turnaround - risk and hazard
- TA performance objectives and management framework
- Maintenance strategy and types of maintenance
- Philosophy of turnaround and reliability centered maintenance
- Impact of turnaround
- Different phases of turnaround

1.1 Overview and strategy

Project management has evolved in order to plan, coordinate and control the complex and diverse plant activities of the manufacturing project of which the basic objectives are performance, cost and time. The triangle of objectives illustrates the interrelation between the three (refer Figure 1.1).

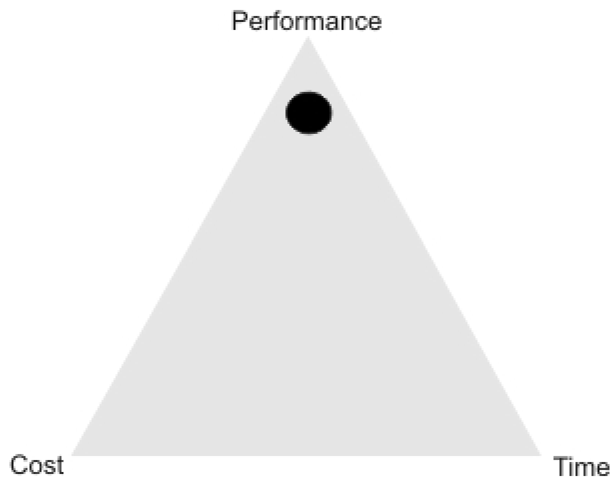

Figure 1.1
Triangle of objectives

In recent years, owners of manufacturing processes and industrial plants have recognised that the maintenance of equipment assets is a reality. They are showing tremendous interest in plant shutdown and turnarounds. In any industrial plant, inspection and minor maintenance work are taking place "on line" but it has to undergo a scheduled process outage for the major maintenance work and this outage is referred to as "Plant shutdown". The management of a plant shutdown is known as the "plant turnaround" which is a continuous process, starts well before the plant is taken off-line and continues for a period of time after the scheduled major maintenance work has been completed.

Plant shutdowns for scheduled major maintenance work is a complex, expensive and time-consuming maintenance project, which always has a negative financial impact due to both loss of production revenue and a major cash outlay for the plant turnaround and shutdown expenses. The positive impacts are an increase in equipment asset reliability, continued production integrity and a reduction in the risk of unscheduled outages or catastrophic failure.

1.2 Turnaround management

Turnaround management is a project management with all its main elements and a number of features that make it unique. Turnaround management is primarily concerned with repair, replacement, alteration and refurbishment of malfunctioning items whereas project management ensures creation of something new. Some of the other unique features of turnaround management are tabulated below (refer Table 1.1) for easy comparison between the two.

Table 1.1

Features of turnaround management

Project management	Turnaround management
Scope is static, visible and is usually well-defined (drawings, specifications, contracts and permits, memos, etc.). Few changes occur during execution.	Scope is dynamic, hidden and is usually loosely defined (past turnaround experience, inspection reports, operations requests and historical estimates). Many changes occur as inspections are made.
Projects are organized around cost codes / commodities. It can be planned and scheduled well in advance of the project.	Turnarounds are work order based. Planning and scheduling cannot be finalized until the scope is approved, generally near the shutdown date.
Generally does not require safety permits to perform work.	Turnaround work requires extensive permits for every shift.
Projects measure time in days, weeks and months in which schedules are updated either weekly or monthly and manpower staffing requirements usually do not change.	Turnarounds measure time in hours or shifts in which schedules are usually updated every shift; daily and manpower staffing requirements change during execution due to scope fluctuations.
Project scope is usually all mandatory and project schedules are uncompressed. Schedule acceleration can be used to correct slippages in the critical path.	Turnaround scope is flexible and a large percentage of work can be postponed if necessary. Turnaround schedules are compressed and cannot be corrected by accelerating the schedule.

1.3 Component of work

Turnaround consists of two types of work: routine and unexpected. Very few plants have had turnaround successes and inconsistency has been the trademark of plant shutdowns and turnarounds. Operating environment i.e. delivery of materials, availability of labour, the weather etc. imposes uncertainties on any normal project whereas in a turnaround an additional degree of uncertainty is involved i.e. degree of wear or damage which is unknown until the plant/equipment is opened for inspection.

1.4 Principle of methodology

It involves the mobilization of a huge number of workers, material and equipment to the site to complete the turnaround work within the stipulated time including the emergency work that came to the fore during the turnaround process. Demobilization is also a part of the turnaround process.

Turnaround requires effective and efficient management of time, safety, technical and logistics for better control of the routine work so that there is time to deal with the unexpected work, unknown at the pre-shutdown planning stage. Tom Lenahan rightly said, "If the routine is under control, there is time to deal with the unexpected but if the routine becomes unexpected, the unexpected may become catastrophic."

1.5 Complexity of technology

Every day it becomes more obvious that the design and building of manufacturing plants are getting more complex and equally expensive to maintain the old technology. Hence there is a need for a major scheduled outage for maintenance work on the physical assets to make significant design changes in piping, equipment, buildings and structures and to update critical job procedures to get rid of the problem of ageing.

There is a continuous search for perfect Management of Change (MOC) for economic viability. It will control and justify any significant changes and therefore the turnaround costs. The initiation of the MOC process begins before implementation, to allow for interdepartmental review and input, including senior management review and authorization. Normally, replacement-in-kind or routine job procedure updates, do not require an MOC but it is essential with large scale assets in which maintenance can only be carried out once the plant is taken off line, decontaminated and made safe.

1.6 Complexity of business

Ever increasing global competition forces the management to continuously upgrade and improve both plant and product by increased production *vis-a-vis* market share. There is a tremendous need for effective planning and management of plant maintenance work as it separates the excellent performer from the average. The ongoing quest for 'smart' maintenance management by continuous upgrading ensures more business at a reduced cost.

Sometimes several negative thoughts generate negative sentiments and it becomes difficult to excite plant/process owners as far as plant shutdowns and turnarounds are concerned. Some of the common negative thoughts given below also depend upon the background, responsibility and position of the process/plant owner.

- Stress and conflicts within the organization
- Long working hours and personal fatigue
- No production
- Moving away from normal routine work
- Higher safety and environmental risks
- Financial impact
- Delayed schedule and cost overrun
- Impact on company's bottom-line

Negative sentiments tend to translate into several risks and fears. In some cases process owners prefer to continue production without frequent shutdowns and turnarounds as it affects the profitability of the unit. The advent of technology enables to monitor and maintain the plants/process on-line while avoiding the costly outages in terms of safety, reliability, environment and profitability. If properly implemented, improvement in the turnaround management function invariably guarantees world-class results and helps in improving the company's bottom line performance.

In spite of the awareness of turnaround management advantages and their benefits, most companies still lack full appreciation of the potential rewards and have shied away from implementing the best turnaround management processes and practices. Non-acceptance is largely due to false pre-conceptions and the traditional mind set which need to be aggressively addressed and changed by company management.

1.7 Complexity of maintenance

Plants are to be maintained like any other industrial assets as the plant turnaround is a never ending process and no single plant can keep on producing without shutdown. Plant and process owners have the unobtainable quest for production without shutdown and ultimately realize that tackling the plant shutdown is a must in a more organised and systematic way in the form of turnaround management. It ensures greater safety and shorter plant shutdown or increased plant availability for optimal output in terms of quality and quantity.

Some of the advantages of a successful turnaround are given below:

- Plant becomes safer with fewer environmental risks
- Higher operational reliability in order to supply on-spec products to customers
- Higher mechanical integrity ensures extended equipment life
- Increased production and energy efficiency
- Reduced risk of emergency shutdown due to mechanical failures or production disruptions
- Ensures compliance with regulatory, insurance and certification requirements
- Tie-ins with new capital and de-bottleneck projects

1.8 Complexity of life

'Shutdown and turnaround' is an integral part of the production process to achieve minimum risk to the enterprise.

Around the world, turnaround experts are following some basic principles, routines and procedures while managing complex projects like petrochemicals, fertilizers, chemicals etc. to avoid cost and time overrun. Poor past turnaround performance lengthen the intervals between turnarounds from 1-2 years to 4/5/8 years. Process plant owners are interested in well-planned turnaround management because of the following facts:

- Turnaround performance has a long-term impact on the plant's mechanical integrity and operational reliability.
- Turnaround improves the plant's operational efficiency and makes it suitable for the ever-increasing global competitive market.

1.9 Turnaround - risk and hazard

Turnaround is an expensive process funded from the profits and can be spread over a number of years like other industrial capital expenditure to lessen the impact on one year's profit. The cost of turnaround includes the number of days the plant is not producing and it helps to estimate the actual impact on the business. Turnaround ensures plant reliability provided it is properly planned, prepared and executed under the guidance of qualified and trained management leaders. To the contrary, poor decisions, bad workmanship, incorrect materials etc. damage the reliability of the plant.

The result of a detailed survey on turnaround performance (refer Figure 1.2) is really an eye opener to management and business leaders. A large number of workmen, machinery, equipment, etc., gathering at the turnaround site reverse all characteristic of normal routine. The turnaround increases the potential for harm to people, property and the environment. Safety procedures should be followed strictly to avoid potential loss, which rises exponentially during the turnaround period. Unexpected problems and uncertainties suffered during turnaround activities lead to cost escalation as well as extended shutdown periods. The total loss of revenue is quite large.

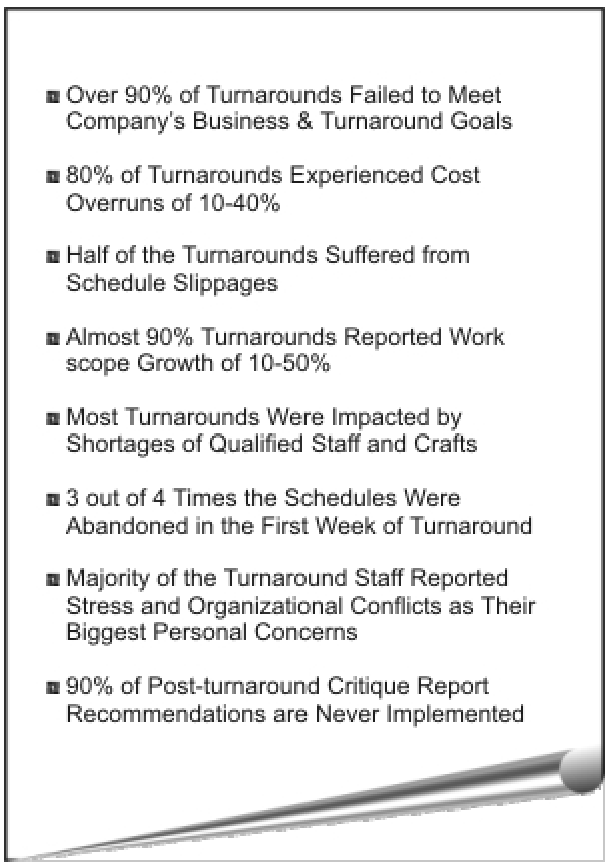

Figure 1.2
Consortium study on TA performance results

1.10 Business strategy

Webster's Dictionary explains strategy as a careful plan or method to achieve an established goal. In this context, strategy is an overall approach to accomplish key objectives of turnaround management i.e. the turnaround management should be aligned with maintenance objectives, production requirements and business goals. Focusing on only one aspect of the turnaround priorities will invariably lead to poor business decisions. Turnaround success can't depend upon mere luck and the success should be judged from the following perspectives (refer Figure 1.3):

- Business
- Operational
- Execution and
- Organizational

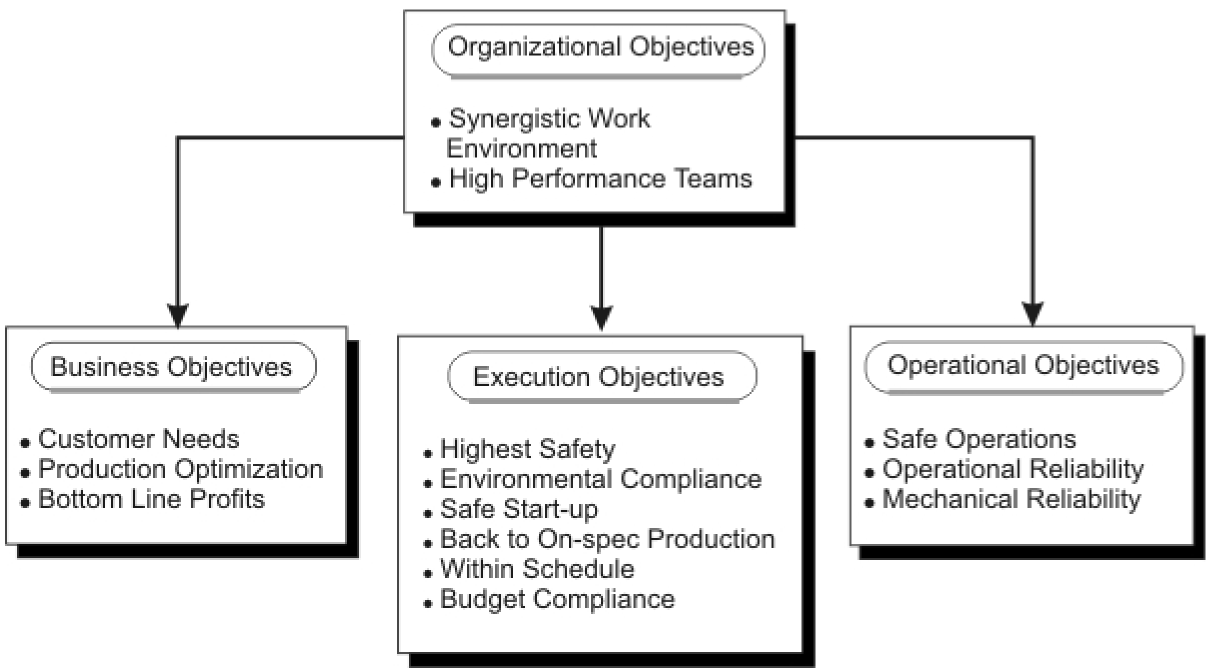

Figure 1.3
TA performance objectives

Strategic turnaround planning is a team effort initiated at the initial planning phase to design an optimum strategy to meet the business and operational goals of the company. The real challenge for the turnaround management team is to achieve an optimum balance between the company's business and financial goals and the plant's operational and mechanical integrity needs. Figure: 1.4 shows the framework to transform a company's business objectives into high performance turnaround results.

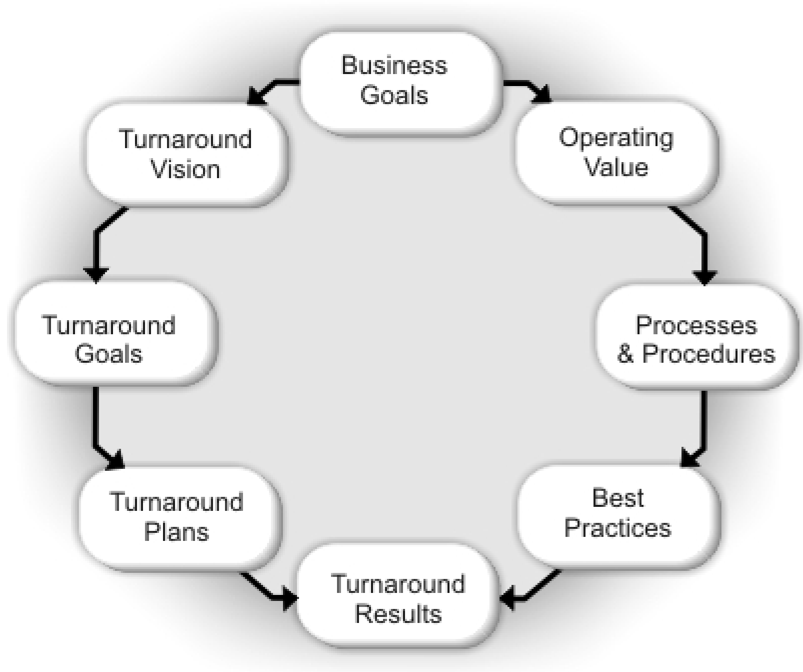

Figure 1.4
TA management framework

1.11 Maintenance strategy

Turnaround result mainly depends on the participative efforts of the team. Statistics reveal that the absence of management leadership affects the turnaround performances. Generally senior managers form a steering committee headed by a senior manager who is responsible for the strategy of the turnaround. A typical example of a turnaround management steering committee is shown in Figure 1.5.

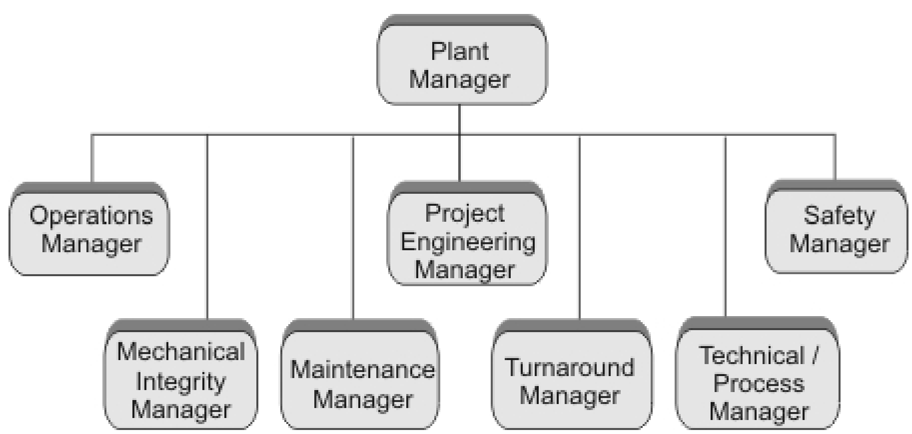

Figure 1.5
TAM steering committee

The participants can be varied to reflect the company's organizational structure and the turnaround's unique requirements. A strategy must be devised for the long-term, considering the future requirements. The strategy team meets regularly throughout the year to analyze current performance and past practices. Past turnaround history always provides a sequence or trend for every equipment/events, which will be essential to map out future turnarounds. Despite collating all sorts of data related to past and present practices, it is quite difficult to formulate a future turnaround strategy that is free of uncertainty, but the creative and participative approach of the steering team definitely reduces the degree of uncertainty. The steering committee poses a typical set of questions (discussed in detail in Chapter 2) at an early stage of the turnaround to minimize the impact at the bottom line, a must for a successful turnaround.

1.12 Types of maintenance

The purpose of maintenance is to make machinery and equipment available for production purpose, fulfilling their technological functions as specified and as economically as possible, which means that the output quality and quantity from each machine or equipment will conform to specified purposes. After some use all machines and equipment are subject to wear which can be reduced by taking care of it i.e. lubrication, cleaning, timely inspection and maintenance. The machines need to be attended to even when not in use, ensuring that any defect or damage is taken care of. Maintenance systems can be grouped into the following major groups:

Routine maintenance

Routine maintenance is the first step in approaching a modern maintenance system. It involves joint planning by production and maintenance departments. This needs to be done well in advance to ensure equipment availability for maintenance without affecting the production schedule. The maintenance team has scheduled periods during which machines and equipment are made available to effect repairs, resulting in no waste of otherwise idle time.

Predictive maintenance

Predictive maintenance is one step ahead of routine maintenance, which not only decides the 'when' and the 'where' of maintenance but also 'what' and 'by whom'. Experience in routine maintenance is further extended to allow for a detailed analysis, involving more precise planning of work (estimating the work content of the jobs to be done) and allocation of labour.

Preventive maintenance

Preventive maintenance is a further improvement on predictive maintenance and answers the 'why' for the maintenance work. It involves the policy of replacement and modification rather than repair. Periodical inspection of the plant is essential in order to diagnose the problem and to plan the required maintenance. The objectives of a preventive maintenance scheme are:

- To prolong the working life of the equipment and assure optimum availability.
- By minimizing the wear and tear, preserve the value of the plant.

- To safeguard the investment.
- To ensure safety of the equipment and the personnel.
- Keep the productive assets in good working order.

Breakdown maintenance

An independent maintenance team does breakdown maintenance whenever there is an interruption or restriction of production and the production staff summons an emergency repair service. This method reduces the machine availability and overall mechanical efficiency in the long term.

1.13 Philosophy of turnaround

It is confirmed that irrespective of any amount of sophisticated maintenance systems being enforced, shutdown maintenance cannot be avoided altogether. Therefore the ultimate goal is to introduce more and more sophistication in the preventive maintenance techniques to minimize the need of maintenance between the two turnarounds.

Actually to be aligned to the business strategy, the evolution of asset management should be driven by a philosophy of maintenance prevention but not from the preventive maintenance perspective, which is primarily driven by technical considerations. Zero maintenance may not be possible but can be minimized by asking the very basic question "whether the turnaround is at all necessary." It is the most crucial question as the turnaround involves quite a substantial amount of money and deserves serious consideration as to its potential payback. While calculating the cost of a turnaround it is crucial to evaluate the detailed list of tasks regarding the following aspects:

- Statutory requirement
- Equipment maintenance required as per the supplier's recommendation
- Actual requirement evolved by experience and historical data
- Getting into the root of chronic problems and rectification
- Unnecessary ritual tasks
- Wear and tear due to improper process fluid and other consumables
- Problems due to original design failure, non-standard procurement, improper installation and commissioning
- Inadequate standard operating procedure leading to faulty operation
- Faulty plant operation due to incompetence across the level
- Improper preventive maintenance
- Lack of environmental concern and inadequate protection
- Continuously operating above the designed load

After thorough analysis and if management decides to proceed with the turnaround, it is preferable to analyze each single task in the same way to ensure that the desired outcome is achieved with the minimum output.

1.14 Reliability

Components, equipment, systems and people are not perfect and are not free from failures. In the real world we fall short of perfection and everything is subject to failure.

The natural law of entropy expresses the lowest energy state as a failure. Thus we spend time and resources extenuating effects of failures. Nothing lasts forever without failure.

Reliability ensures the dependability of equipment or component, process/product to such an extent to which an experiment, test or measuring procedure yields the same results on repeated trials. It is the trait of being dependable or reliable. Reliability is the probability that a component, system or process will function without failure for a specified length of time when operated correctly under specified conditions.

Management must set the reliability policy that integrates the safety, quality, risk and financial requirements for the company to achieve the business objectives. Reliability engineering - the collection of tools - is concerned with predicting and avoiding failures. It is a strategic task to quantify reliability issues to know why, how, how often and costs of failures.

The financial exposure, \$risk = (probability of failure) X (\$consequence). Reliability is determined largely by the quality of design and the attainable reliability inherent in the design called “intrinsic reliability.” However, the achieved reliability is usually less than the intrinsic reliability because of the unanticipated environment during use, lapses in quality of conformance, inadequacies in maintenance, etc. The term “operational reliability” is sometimes used to distinguish attained reliability from intrinsic reliability.

Reliability reduces maintenance costs and eliminates machinery downtime. Reliability tools are used for predicting failures and finding cost effective alternatives. Failure rate is the number of failures per unit time and when the failure rate is plotted against a continuous time scale, the resulting chart (refer Figure 1.6) “bathtub curve” exhibits three distinct periods or zones.

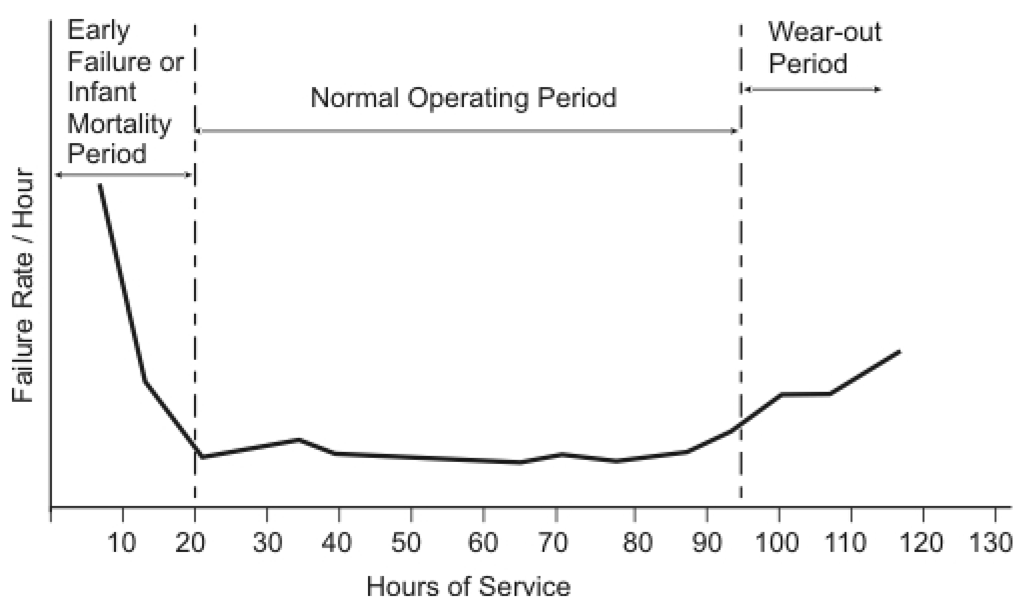

Figure 1.6
A typical ‘Bathtub curve’

The infant mortality period: High failure rates are observed in the initial period of usage that are caused due to:

- Initial design or manufacturing problem
- Improper usage
- Other identifiable causes

The constant failure rate period: The failures result from the limitations inherent to the design plus accidents caused by usage or poor maintenance. Proper operation and maintenance can reduce these; whereas the basic failure rates can be reduced only by basic redesigning.

The wear-out period: Failures due to old age and a reduction in failure rates require preventive replacement of these affected components before they result in catastrophic failure.

Generally users are concerned with the length of time that a machine/equipment will run without failure i.e. for repairable products, "time between failures" or TBF, and for nonrepairable products, "time to failure" are critical.

1.15 Conventional methods used to achieve reliability

Responding to the need for increased production efficiency and plant reliability, conventional methods i.e. condition monitoring have been developed to meet the demanding operational environment. Condition monitoring technologies imply the use of advanced technologies in order to determine equipment condition and potentially predict failure. It includes, but is not limited to, technologies such as:

- Vibration analysis
- Infrared thermography
- Tribology
- Ultrasonics

There is a need for asset effectiveness i.e. extracting the maximum profit from the minimum investment in plant and equipment. We can achieve this through the use of condition monitoring technologies in one of the following five ways:

- By improving equipment reliability through the effective prediction of equipment failures eventually resulting in failure avoidance.
- By minimizing downtime
- By maximizing component life by avoiding the conditions that reduce equipment life i.e. ensuring ongoing precision alignment, minimal lubricant contamination etc.
- By utilizing condition monitoring techniques to maximize equipment performance and throughput
- By minimizing condition-monitoring costs – it improves the consistency and accuracy of failure diagnosis as well as reduces the labour requirement to assess equipment conditions.

Vibration analysis
Vibration signatures are monitored using the most advanced equipment and data is refined to such a degree that not only are mechanical faults such as worn bearings and misaligned shafts easily identifiable, problems can also be detected before they have a chance to contribute to component breakdowns. Vibration analysis consists of assessing the vibration levels and then comparing these with some warning levels above which some corrective action is required.

Tribology
It is a multidisciplinary science dealing with friction, wear and lubrication of interacting surfaces in relative motion. In any machine there are lots of component parts that operate by rubbing together i.e. bearings, gears, cams and tappets, brakes, piston rings etc. Samples taken from on-site machines undergo thorough testing processes, which can pinpoint true mechanical faults, isolate deteriorating components and detect any ingress of dirt or water that will quickly ruin the effectiveness of oil.

Thermography
Thermography assists in maintaining equipment reliability and industry can maximize the potential of this highly visual, intuitive condition-monitoring technique to prevent the failure of equipment and other crucial items. One of the benefits of thermography is its versatility, having the capability to assess the condition of a variety of applications, including process equipment and sometimes even the process itself. The most common use of thermography is within the electrical field. Thermography normally is used as a noncontact, nondestructive form of monitoring. It has the advantage of assessing equipment (motors, pumps, fans, gearboxes, compressors, etc.) operating under normal loads and environmental conditions. Mechanical equipment naturally produces friction when running and the machine emits a thermal signature as mechanical energy is converted to thermal energy. The information can be very useful when planning structured downtime to carry out planned maintenance.

Laser-alignment
In 1980, the world's first laser alignment system for the installation and monitoring of the alignment of rotating machines was introduced to the market. A range of unique sensors and laser systems was developed that can automatically measure offset and angular displacement in 5 axes. The laser alignment products are currently available for various specific purposes i.e. rotating machine base alignment system, rotating machine laser alignment system, bearing pocket and turbine diaphragm alignment system.

1.16 Modern methods

The modern view of maintenance is that it is all about preserving the functions of physical assets. The possible maintenance policies are grouped under four headings:

Corrective – Wait until a failure occurs and then restore the asset to productive capability as quickly as possible.

Preventive – Believe that regular maintenance attention will keep an otherwise troublesome failure mode at bay.

Predictive – Examine the 'vital signs' and infer what the equipment is trying to tell us.

Detective – Applies to the types of devices that only need to work when required and do not tell us when they are in the failed state e.g. a fire alarm or smoke detector. They generally require a periodic functional check.

Apart from the detective maintenance, there is a struggle within the organization to choose the right type between the other three. It was realized that the solution was tied up in long term continuous improvement and two different strategies were developed i.e. Total Productive Maintenance (TPM) and Reliability Centered Maintenance (RCM).

Total productive maintenance (TPM)

TPM is a manufacturing led initiative that emphasizes the importance of people, a 'can do' and 'continuous improvement' philosophy and the importance of production and maintenance staff working together. In the ever changing world of business, TPM is concerned with the fundamentals of business processes to achieve improvements in cost, quality, speed etc. The principal measure is known as the overall equipment effectiveness (OEE). Three measurables of OEE are availability (Time), performance (Speed) and yield (Quality) which are tied to 'six big losses' (refer Figure 1.7). When the losses from Time X Speed X Quality are multiplied, the resulting OEE value shows the performance of any equipment or product line.

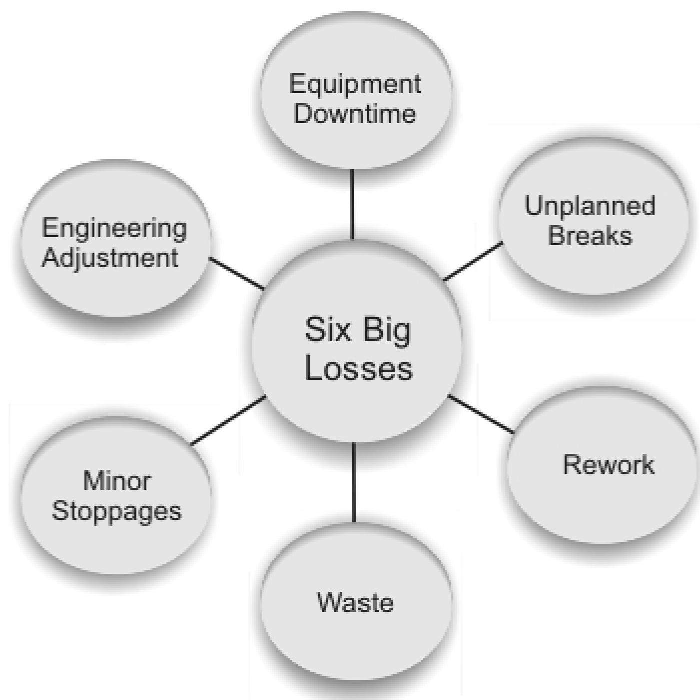

Figure 1.7
Six big losses

Some of the major advantages of the TPM approach include:

- Better understanding of the performance of the equipment,

- Better understanding of equipment criticality and where it is worth deploying improvement efforts and potential benefits,
- Improved teamwork between production and maintenance,
- Improved procedures for changeovers and set-ups, carrying out frequent maintenance tasks, better training of operators and maintainers, which all lead to reduced costs and better service,
- General increased enthusiasm by the involvement of the workforce.

Reliability-centered maintenance
RCM determines the maintenance requirements of the physical assets within their current operating context, and TPM ensures that these requirements are met as cheaply and effectively as possible. Since the 1930s, the evolution of maintenance can be traced through three phases. RCM is rapidly becoming a cornerstone of the third phase.

Phase -I
It covers the period up to World War II. As industry was not very highly mechanized, downtime did not matter much and prevention of equipment failure was not a very high priority. Most equipment was simple, reliable and easy to repair. There were only simple cleaning, servicing and lubrication routines.

Phase -II
Things changed dramatically during World War II. By the 1950s machines of all types were more numerous and more complex. As the dependence grew, downtime came into sharper focus and the concept of preventive maintenance was developed. The sharp increase in maintenance costs led to the growth of maintenance planning and control systems.

Phase -III
Figure 1.8 shows how the expectations of maintenance have evolved. It has been noticed that there is less and less connection between the operating age of most assets and its failure.

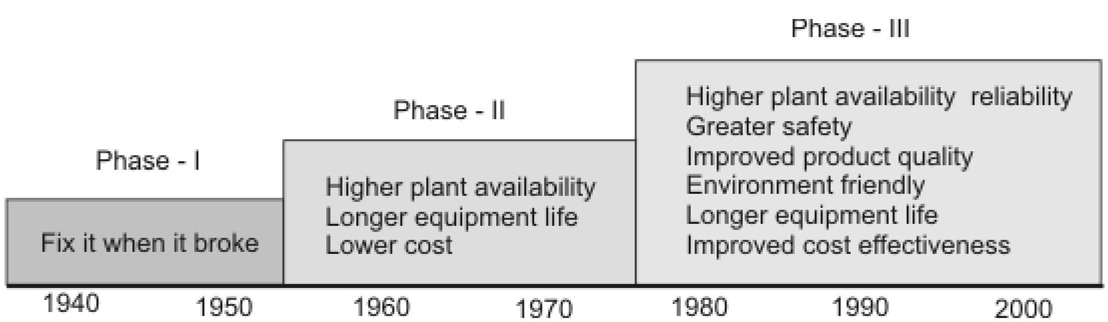

Figure 1.8
Growing expectations of maintenance

Figure 1.9 shows how the earliest view of failure was simply that as things got older, they were more likely to fail. A growing awareness of 'infant mortality' led to widespread belief in the 'bathtub' curve.

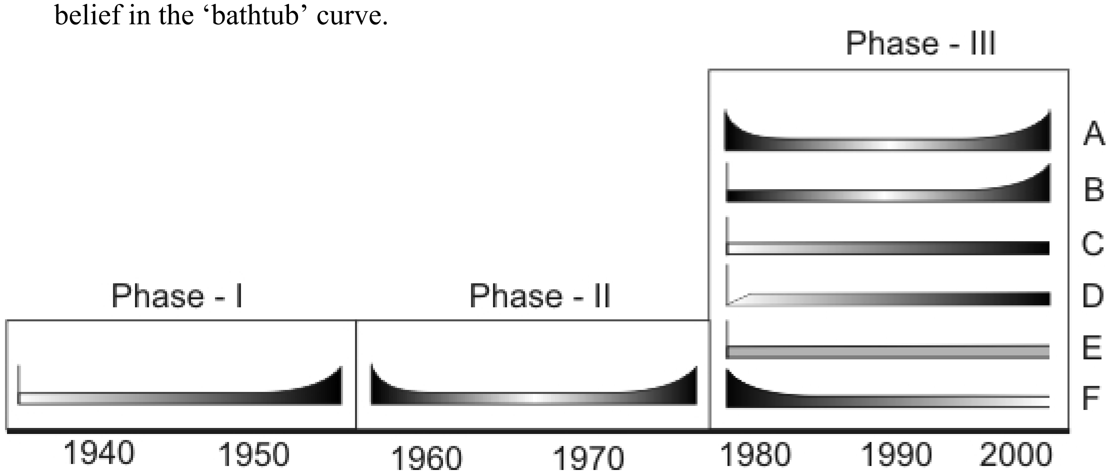

Figure 1.9
Changing views on equipment failure

However, research has revealed that there are six failure patterns that actually occur in practice. Pattern A is the well-known bathtub curve. It begins with a high incidence of failure followed by a constant or gradually increasing conditional probability of failure; then by a wear-out zone. Pattern B shows constant or slowly increasing conditional probability of failure, ending in a wear-out zone (refer Figure 1.10).

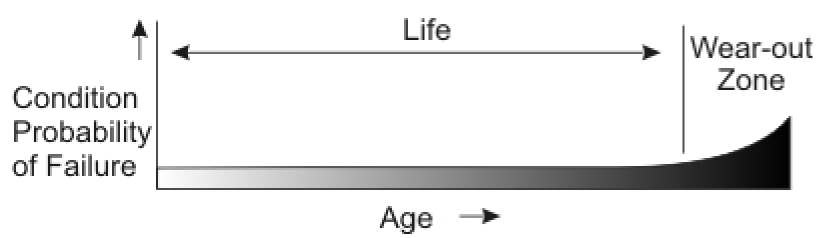

Figure 1.10
Increasing conditional probability of failure

Pattern C shows a slowly increasing conditional probability of failure, but there is no identifiable wear-out age. Pattern D shows a low conditional probability of failure when the item is new or just out of the shop, then a rapid increase to a constant level. Pattern E shows a constant conditional probability of failure at all ages. Pattern F starts with high infant mortality, which drops eventually to a constant or very slowly increasing conditional probability of failure.

The reliability-centered maintenance (RCM) process entails the following seven basic questions about the asset or system under review –

- Functions: What are the functions and associated performance standards of the asset in its present operating context?
- Functional failures: In which ways does it fail to fulfill its functions?
- Failure modes: What causes each functional failure?
- Failure effects: What happens when each failure occurs?
- Failure consequences: In what way does each failure matter? Hidden failures, safety or environmental, operational and non-operational.
- Pro-active task: What can be done to predict or prevent each failure?
- Default tasks: What should be done if a suitable proactive task cannot be found?

RCM provides strict criteria for prediction or prevention of failure. RCM divides proactive tasks into three categories:

Scheduled restoration – Remanufacturing a component or overhauling an assembly at or before a specified age limit, regardless of its condition at the time.

Scheduled discard – Discarding an item at or before a specified life limit, regardless of its condition at the time.

On-condition tasks – Most failures give some warning that they are about to occur. These warnings are known as potential failures, and are defined as identifiable physical conditions that indicate that a functional failure is about to occur or is in the process of occurring. They are called on-condition tasks because items are left in service on condition that they continue to meet the desired performance standards. On-condition maintenance includes predictive maintenance, condition-based maintenance and condition monitoring.

RCM recognizes three major categories of default actions:

- Failure-finding
- Redesign
- No scheduled maintenance

If a proactive task cannot be found that is both technically feasible and worth doing, suitable default action must be taken. The essence of the task selection process is as follows:

Hidden failures

A proactive task is worth doing if it reduces the risk of the multiple failures associated with that function to an acceptably low level.

If such a task cannot be found, a scheduled failure-finding task must be performed.

If a suitable failure-finding task cannot be found, the secondary default decision is that the item may have to be re-designed.

Failures with safety or environmental consequences
A proactive task is only worth doing if it reduces the risk of that failure on its own to a very low level if it does not eliminate it altogether.
If a task cannot be found which reduces the risk of the failure to an acceptably low level, the item must be redesigned or the process must be changed.
Failure with operational consequences
A proactive task is only worth doing if the total cost of doing it over a period of time is less than the cost of the operational consequences and the cost of repair over the same period. It must be economically viable.
If it is not justified, the initial default decision is no scheduled maintenance. If the operational consequences are still unacceptable, the secondary default decision is again redesign.

Failure with non-operational consequences
A proactive task is only worth doing if the cost of the task over a period of time is less than the cost of repair over the same period. It must be economically viable.
If not, the initial default decision is again no scheduled maintenance, and if the repair costs are too high, the secondary default decision is once again redesign.

This approach means that proactive tasks are only specified for failures which really need them, which in turn leads to substantial reductions in routine workloads. This routine work also means that the remaining tasks are more likely to be done properly. This together with the elimination of counterproductive tasks leads to more effective maintenance.

1.17 TA impact

Financial implications

At the time of planning a turnaround, it is necessary to consider all those related costs and not only the direct cost of planning and execution. The work scope is the basis upon which all other aspects of the turnaround rest. The cost of a turnaround is influenced by the work scope and early cost estimation helps the management to allocate a sufficient budget.

Management is also able to exercise their discretion by eliminating some of the elements from the work scope to accommodate the turnaround within the available funds. The amount to be budgeted for the turnaround depends upon the company's maintenance policy, age and nature of the plant and the work scope.

The company loses revenue during turnaround days as the plant is off line; as well as just after the turnaround days when plant production is below par in terms of quantity and quality.

It is also necessary to consider the salary and wages of the plant personnel who are paid for production and during turnaround as the plant is not producing their wages and salary must be added to the turnaround cost.

Current plant performance

The turnaround work scope also depends upon the degree of preventive maintenance carried out in-between the turnarounds. It is often observed that there is a tendency to push part of the preventive maintenance into the turnaround work scope without realizing its effect on costs. Actually, performing a task during the turnaround is definitely costlier than performing the same task during normal operation.

Another negative effect is unnecessarily overloading the turnaround process that leads to a diversion of the critical resources i.e. money, labour, equipment etc. which, in turn, extends the turnaround duration or postpones some of the elements of the turnaround work scope. The list of work has to be generated on the basis of present performance and it must only include those works that cannot be done at any other time.

Historical data

Turnaround ensures the perfect condition of the plant during production and the reliability must be at least be the same or better after the turnaround. To protect the reliability of the plant it is advisable to dig into past turnaround information and performances, which helps to formulate the future turnaround. Past turnaround history provides the overall guidelines regarding the ratio of uncertainty which arises during the execution phase to the planned work. It also helps the management to estimate the probable cost escalation of the turnaround due to emergent work. It is always safer to have cost estimation with 10% extra for uncertainty. Management has to ensure that the plant personnel have taken care of all the problems related to past levels of emergent work.

Turnaround organization

Turnaround involves a number of events that has to be taken care of during the short period of time and it can only be possible if management possesses the required expertise that is absolutely different from that of operating and maintaining the plant under normal conditions. Management has to strategically decide whether to outsource professionals to conduct the entire show against the internally available resources. Companies interested to use their internal resources must ensure that

- there are enough people available within the company as per the requirement; and
- they are competent enough to carry the role.

The required expertise must be as per the best in the field and the ultimate goal should be ‘lowering the cost of each subsequent turnaround’. Even though the plant is aging, the rising costs can be controlled by the application of superior technology and knowledge and it can be achieved only by an experienced, professional event management group.

Once it is decided to outsource the total turnaround package, it is important to select the best one and that can be done by using some basic information i.e. credibility of the contractor and the track record especially the financial claims against the client for variations to contract. The decision needs to be taken whether to employ a control group to monitor the performance of the contractor.

Project scope of work

A turnaround consists of maintenance and project work and the ratio of these two may be different for different turnarounds. In a running plant, a project is a discrete package of work that has to be performed to improve the plant performance, which may be in terms of the quality or quantity of the products or may be satisfying to the statutory requirement.

Every single project has to be tested on three counts:

- Necessity – Is the project necessary? How will it improve quality/quantity and safety?
- Desirability – Is it desirable at this time in the life of the plant? Too early or too late?
- Payback – What is the payback period? Increased profit or reduced cost?

It is important that the plant performs better than it did before the turnaround and each project must be viable from a business point of view. The turnaround manager is responsible for the entire maintenance and project work. Project managers execute different projects independently and work coherently being a part of a single integrated plan under the turnaround manager.

Maintenance scope of work

Generally, maintenance work can be categorized into three classes – major tasks, small tasks and bullwork. The overhauling of large machinery/equipment i.e. diesel generator overhauling, re-traying of a large distillation column etc. requires engineering expertise and is considered a major task. The cleaning of the heat exchanger, deodorizer etc. is considered a minor or small task, which involves careful adherence to equipment specifications.

Overhauling a large number of valves, steam traps, pumps, motors and other small equipment/installations (gauges, flow meter, PID controller etc.) is the real bullwork and needs proper scheduling. It is always the bullwork that creates problems in the turnaround, as there is a natural tendency of not giving it enough importance (due to its large numbers and wide dispersion) during the planning stage like other major tasks that are planned down to the last detail.

Each and every major task is required to be evaluated from a business point of view but not that it is technically desirable. If so the management must defer that particular task until a later opportunity. Events surrounding the critical path are to be given special consideration to ensure timely completion of turnaround work.

There is a need for an effective risk analysis related to the turnaround and must be defined as ‘the numerical probability of loss occurring’. The nature of risks related to people, production and environment must be analyzed and assessed by the managers. The acceptable level of risk depends upon the experience, ability and confidence of the managers.

1.18 Psychology of TA

A project creates something new but turnaround is concerned with repair, replacement and renovation of an existing plant. The planning and preparation is done when the plant is in operation. Turnaround involves disruption of the normal routine of a plant and a messy situation without any production involving lots of people, machinery and equipment at the production site. It may generally create a negative attitude among the operators as the plant was running quite well and it is felt that management is shutting down to unnecessarily dismantle the plant.

Moreover, they suddenly consider themselves as unwanted and their technical records and operating procedures are subjected to scrutiny in the hands of some outsiders. All these events may cause a low morale. On the other hand, a group of energetic people involved in planning and execution finds the other group less than enthusiastic and sometimes even obstructing. All these complexities can be termed the 'psychology of turnaround' that plays an important role in any successful turnaround.

1.19 Team building

All great ideas and good intentions to improve the turnaround management capability do not mean much unless there is a strong commitment and necessary leadership support to translate these visionary concepts into realities. Companies that have effectively implemented innovative turnaround management approaches have benefited by achieving their business objectives and turnaround goals. A solid team is essential for the success of the turnaround process where different teams such as project, maintenance and production are uniquely integrated and are concerned with creating something new in terms of plants, programmes or products. The turnaround management is primarily concerned with the replacement, repair and refurbishment of the damaged or malfunctioning equipment/parts. Every individual of the team must share the responsibility for its success and contribute positively. It is not uncommon to have over 50-70 different contractors, vendors and suppliers participating in the turnaround execution.

The steering committee has the major responsibility to ensure that each and every individual is properly integrated and focused in the system toward common goals. This will require the facilitation of several team building and alignment sessions with different companies and at different levels of the organisations. Persistence and consistency on the part of management in conveying the message to implement new turnaround concepts and changes are essential. Management must address the issue and involve all personnel in a single cohesive team by appropriate training, negotiation and two-way communication to get rid of this human problem that is considered much tougher than any technical obstacle.

Typically, leadership should watch out for the following common barriers that may send mixed signals and build resistance to change:

- Absence of clear turnaround vision and expectations
- Poor morale and lack of "buy-in" to change
- Lack of company/management support
- Conflicting goals and priorities
- Role conflicts and hidden agendas
- Insufficient resources and funding
- New concepts that are inconsistent and fragmented
- The absence of training and orientation

The real intention of these alignment sessions is not only telling the field staff what is expected of them, but also to benefit from their knowledge and experience. This initial involvement and encouragement for new ideas will eventually lead to true teamwork and exceptional turnaround results such as,

- Common focus to achieve turnaround goals
- Buy-in of turnaround plans by execution groups
- Better communication and interface channels
- Clear definition of roles, responsibilities and authority levels
- Innovative and synergistic work environment
- Benefiting from everyone's experience, knowledge and ideas
- Recognize and correct any weak areas
- Streamline field logistics
- Efficient field decision-making

The achievement of the above objectives ensures a safe, efficient and conflict-free turnaround execution.

Alignment sessions ensure trust & common goals

1.20 Turnaround organization

The turnaround manager plans, prepares and executes the whole event with the help of various people of different knowledge and experience levels who are accountable for the turnaround. These human resource groups are classified as per their role or function:

Local group: Consists of plant personnel who are familiar with the technical records, operating procedures, history, past performance and present difficulties of the plant.
Work management group: Engineers and planners who are familiar with all aspects of initiation, preparation, execution and termination of turnarounds.
Maintenance group: Internal and external people who are familiar with and experienced in the task and activities related to plant overhauling.
Specialist group: Vendors' representatives and other specialist sub-contractors with specific knowledge and expertise.
Group of project managers: Consists of experienced project managers or engineers.

1.21 Turnaround phases

Phase 1 – Initiation

A turnaround is a cyclical process with four phases which starts with initiation and passes through preparation, execution and termination. The initiation phase of the next turnaround must follow on from the present termination phase.

The initiation phase of a turnaround starts from the moment the senior manager considers the necessity of the turnaround and continues over a period of months. In some cases it continues for 20-24 months before the event. During this phase all parameters of the turnaround are defined in detail i.e. analyses breakdown and production problems from the historic data and past events. Strategic issues and objectives are addressed in this phase. Some of the critical issues and activities are tabulated below.

Table 1.2

Initiation phase critical issues and activities

Critical Issues	Critical Activities
– Reviewing historical events/data – Fixing objectives – Deciding policies – Cost minimization – Understanding and balancing constraints – Delegating authority – Measuring and monitoring performance – Flexible approach	– Steering committee is formed consisting of senior managers – Turnaround manager is to be appointed who will be responsible for the entire turnaround – TA manager organizes and leads preparation team for collection and collation of basic data – Plant team provides local knowledge, technical data, plant history and current problems – Plant team issues initial work request forms

Phase 2 – Preparation

Preparation is the most important phase of the turnaround process and may continue for a period of 3 to 18 months depending upon the scale of the event. Members of the preparation team accumulate a large quantity of technical and non-technical data to specify, schedule, resource and cost the large volume of tasks required to execute the turnaround event by validating and transforming those data into a set of plans. The work list is one of the most important elements of this phase and is the foundation of safety, quality, costs, equipment, materials, resources, logistics and turnaround duration. It contains an element of uncertainty as it involves some degree of prediction of the unforeseen activities related to plant equipment that can be minimized by systematic questioning as a part of an analysis of contingencies. Some of the typical questions used for the analysis are: What may go wrong? What faults are likely? What is the cost implication? How much time is required to set that right? What are the contingencies available?

The preparation team along with the plant team challenges and validates the work list that is finalized by the turnaround manager. The plant team and TA team have to communicate regarding the requirements of the turnaround from time to time by means of a series of briefings involving each and every person across the levels. Critical issues and activities related to the preparation phase are given in detail in Table 1.3.

Table 1.3

Preparation phase critical issues and activities

Critical issues	Critical activities
– Leading a small team – Translating policy into a defined project – Reviewing scope of work and preparing activity–wise cost – Reviewing contracts and setting targets – Listing critical activities – Defining and analysing contingencies – Selecting members, constituting teams and delegating work – Formulating rules – Resolving issues arising during the turnaround process – Monitoring delivery, schedule and performance of the entire event.	– Planning officer and preparation team prepare job specification, plan pre-shutdown work and ensure procurement of all necessary items and materials. Allocate contracts and arrange site logistics. – Preparation engineer works up major tasks while turnaround manager optimizes work schedule, organisation chart, cost estimation, expenditure control and resources. – Turnaround manager also finalizes contractor as well as project list. Ensures safety of personnel and quality of the entire event. – Steering group analyses, discusses and provides their decision/approval to the plan forwarded by the turnaround manager.

Phase 3 – Execution

During the execution phase all the planning and preparation are tested against reality and is characterized by the performance of a large number of people of different skills and disciplines within the framework of restricted money and time. Execution continues two to eight weeks, which involves co-ordination of all activities. It is characterized by close monitoring and controlling of event-wise schedule, safety, quality and cost. Effective control can be ensured by breaking down an execution into several sub-phases (refer Figure 1.11).

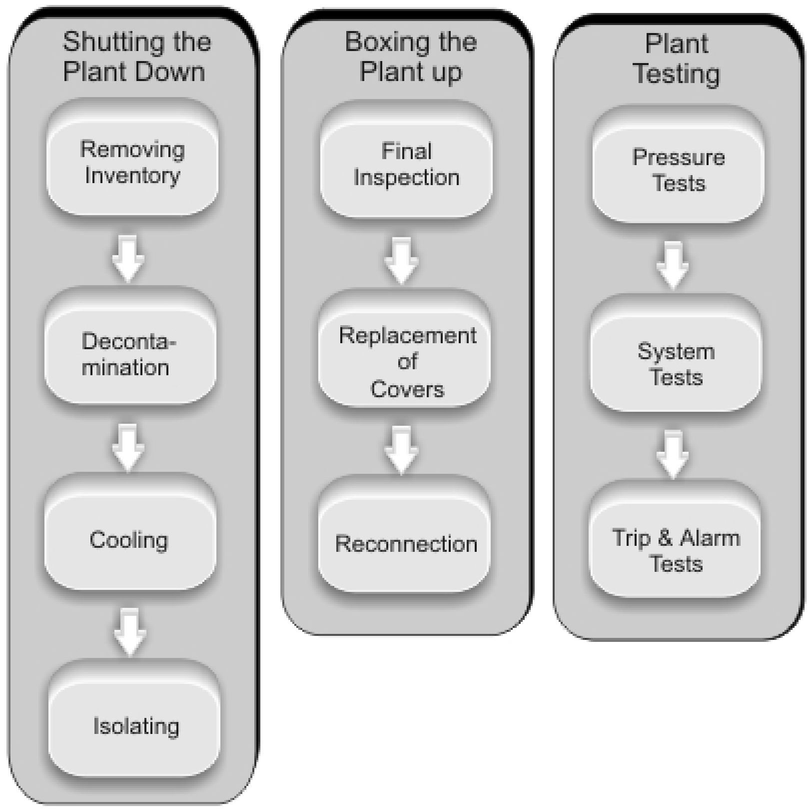

Figure 1.11
Tasks are broken down into sub-phases

There will be a designated person as a first person responsible for each and every sub-phase. Single point responsibility ensures effective coordination and the designated person confirms proper completion of the previous stage of the task. Successful completion of the present task as per the specification and subsequently handing over to the next stage at the earliest possible time are also part of the designated person's responsibility. The execution phase involves following critical issues and activities:

Table 1.4

Execution phase critical issues and activities

Critical Issues	Critical Activities
– Coordinating all activities – Controlling planned as well as emergency work within the schedule – Monitoring safety, quality while minimizing expenditure – Resolving/handling issues	– Plant team shuts plant down as planned to facilitate execution team to perform the turnaround event as per the plan. – Cost and expenditure are analyzed by the control team – Once execution team completes entire work turnaround manager demobilizes execution team and mobilizes start-up team. – Start-up team supports plant team to start-up the plant as planned.

Phase 4 – Termination

The termination phase continues one to two weeks during which time the entire turnaround work is closed and performance is to be reviewed against the plan. It includes reviewing of all completed jobs and re-commissioning activities to ensure safety. This phase ensures that the plant is handed back in a fit condition while ensuring proper debriefing of every member of the turnaround organization to capture the lessons learned from the turnaround that may be useful for future requirement. De-briefing is also useful to control the change in plant operation that has happened due to turnaround. Cost and inventory statements are to be prepared. It is a most crucial phase as most of the accidents usually take place during start-up. Before handing over the plant it is required to clean the plant. Critical activities:

- Start-up team cleans the site and removes all equipment especially brought for turnaround work.
- The plant manager takes charge of the plant after thorough inspection while the turnaround manager demobilizes the start-up team.
- De-briefing can be arranged jointly by the plant and the turnaround manager.
- The turnaround manager generates the final report.

1.22 Summary

Project management has evolved in order to plan, coordinate and control the complex and diverse plant activities of the manufacturing project of which the basic objectives are performance, cost and time.

In any industrial plant, inspection and minor maintenance work are taking place “on line” but it has to undergo a scheduled process outage for the major maintenance work and this outage is referred to as “plant shutdown”. Turnaround management is primarily concerned with repair, replacement, alteration and refurbishment of malfunctioning items whereas project management ensures creation of something new.

Turnaround consists of two types of work: routine and unexpected. It involves the mobilization of huge numbers of workers, materials and equipment to the site to complete the turnaround work within the stipulated time including the emergency work emerged during the turnaround process.

The design and building of manufacturing plants are becoming more and more complex on a daily basis and it is equally expensive to maintain the old technology. Hence there is the need for a major scheduled outage for maintenance work on physical assets to get rid of the problem of ageing.

Ever increasing global competition forces management to continuously upgrade and improve both plant and products by increased production vis-a-vis market share.

Plants are to be maintained like any other industrial assets as the plant turnaround is a never ending process and no single plant can keep on producing without shutdown. 'Shutdown and turnaround' is an integral part of the production process to achieve minimum risk to the enterprise.

Turnaround is an expensive process funded from the profits and can be spread over a number of years like other industrial capital expenditure to lessen the impact on one year's profit.

The turnaround increases the potential for harm to people, property and the environment. Safety systems should be followed strictly to avoid potential loss, which rises exponentially during the turnaround period.

Turnaround success can't depend upon mere luck and the success should be judged from the business, operation, execution and organizational perspectives. The real challenge for the turnaround management team is to design an optimum strategy to meet the business and operational goals of the company. The turnaround result mainly depends on the participative efforts of the team.

The strategy team meets regularly throughout the year to analyze the present performance and past practices. Despite collating all sorts of data related to past and present practices, it is quite difficult to formulate a future turnaround strategy which is free of uncertainty but the creative and participative approach of the steering team definitely reduces the degree of uncertainty.

Maintenance systems can be grouped into routine, predictive, breakdown and preventive maintenance. It is confirmed that irrespective of any amount of sophisticated maintenance system being enforced, the shutdown maintenance cannot be avoided altogether. Therefore the ultimate goal is to introduce more and more sophistication into the preventive maintenance techniques to minimize the need of maintenance between the two turnarounds. Reliability tools are used to predict failures and finding cost-effective alternatives.

Financial implications, current plant performance, historical data, turnaround organization, maintenance and project scope of work are some of the crucial factors that directly impact on turnaround performance. The success of a turnaround depends upon effective team building and handling the 'psychology of turnaround'. The turnaround manager plans, prepares and executes the whole event with the help of various people of different knowledge levels and experience.

A turnaround is a cyclical process with four phases which starts with initiation and passes through preparation, execution and termination. The initiation phase of the next turnaround must follow from the present termination phase.